NAVY EXPERIMENTAL DIVING UNIT

REPORT NO. 7-94

RE-EVALUATING THE DSI CONTAMINATED WATER DIVING KIT'S ABILITY TO PREVENT WATER ASPIRATION INTO THE MK 21 MOD 1 UBA

LT L. J. CREPEAU

APRIL 1994

NAVY EXPERIMENTAL DIVING UNIT

Recommendations

In order to produce a commercially viable product to integrate the multiplexing/ demultiplexing scheme into an optical system, the device would best be reduced in size and the cells assembled and aligned as a single unit.

The greater than expected power losses of the secondary experiment have several potential causes. Probably most of the substantial losses were purely operational. Some losses can also be attributed to the quality of the experimental setup, which was constrained by the limited dollars available for parts. The use of coated optics and optics integrated into one package will improve throughput considerably. The lack of time and money precluded further exploration into these causes, but it is foreseeable that both of these contingencies might be effectively eliminated in future experiments. However, additional research and experimentation would be necessary to fully define and clarify the causes of the unpredicted power loss in the experiments.

Since much of the original interest in the program was to develop a technique for fiber-optic wavelength multiplexing techniques, and since the Faraday rotator concept is probably not best suited for that application, we do not currently plan to submit a phase II proposal to continue this work. However, AstroTerra believes that there are other commercial avenues for which this MUX/deMUX technique is viable. The first is the use of the technique for free-space laser communications, i.e. , at 852nm. The commercial utility of this application must be judged by considering the future of free-space laser communications. The second application is for power combining. Here, communications could be extended to longer ranges by combining the signal from several lasers than would be possible with one laser alone. This scheme will find utility in geosynchronous orbit laser communications. The final application would be the multiplexing and demultiplexing of images rather than simple communications beams. Such systems might be used for astronomical imaging, for example.

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IN REPLY REFER TO:

NAVSEA TA 92-026/93-028

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REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION Unclassified	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT DISTRIBUTION STATEMENT A: Approved for public release; distribution is unlimited
2b. DECLASSIFICATION/DOWNGRADING AUTHORITY	
4. PERFORMING ORGANIZATION REPORT NUMBER(S) NEDU Report No. 7-94	5. MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGAIZ. Navy Experimental Diving Unit 6b. OFFICE SYMBOL (If Applicable) 025	7a. NAME OF MONITORING ORGANIZATION
6c. ADDRESS (City, State, and ZIP Code) 321 Bullfinch Road, Panama City, FL 32407-7015	7b. ADDRESS (City, State, and Zip Code)
8a. NAME OF FUNDING SPONSORING ORGANIZATION Naval Sea Systems Command 8b. OFFICE SYMBOL (If Applicable) 00C	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c. ADDRESS (City, State, and ZIP Code) 2531 Jefferson Davis Highway, Arlington, VA 22242-5160	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO. | PROJECT NO. | TASK NO. 92-026 93-028 | WORK UNIT ACCESSION NO.

11. TITLE (Include Security Classification)
(U) Re-Evaluating the DSI Contaminated Water Diving Kit's Ability to Prevent Water Aspiration into the MK 21 MOD 1 UBA

12. PERSONAL AUTHOR(S)
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13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Test Report	FROM 03/94 TO 4/94	April 1994	

16. SUPPLEMENTARY NOTATION

17. COSATI CODES

FIELD	GROUP	SUB-GROUP

18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number) MK 21 MOD 1 UBA, CONTAMINATED WATER DIVING, WATER ASPIRATION, DOUBLE FLAPPER EXHAUST VALVES, INHALATION PRESSURE, DIVING SYSTEMS INTERNATIONAL

19. ABSTRACT (Continue on reverse if necessary and identify by block number)
A contaminated water diving system (CWDS) protects a diver from exposure to water-borne toxic, volatile, corrosive, or microbial agents. This report followed up on a previous report that evaluated the ability of the Diving Systems, International (DSI, Santa Barbara, CA) contaminated water diving kit to prevent water aspiration into the MK 21 MOD 1 underwater breathing apparatus (UBA). These kits are comprised of double flapper exhaust valves and a secondary water dump valve. Testing was conducted to a maximum depth of 60.6 msw (198 fsw), using respiratory minute volume (RMV) levels as high as 90 liters per minute (LPM). The performance of the valves was continuously monitored using a video camera mounted inside the UBA during testing.
The valves maintained watertight integrity until the inspiratory pressures produced by the mechanical breathing machine far exceeded those that a diver can produce. Thus, the contaminated water kit provides working divers definitive protection from water aspiration. Therefore, NEDU continues to recommend the DSI contaminated water kit for Navy use in the MK 21 MOD 1 UBA.

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT ☐ UNCLASSIFIED/UNLIMITED ☒ SAME AS RPT. ☐ DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION Unclassified

22a. NAME OF RESPONSIBLE INDIVIDUAL	22b. TELEPHONE (Include Area Code)	22c. OFFICE SYMBOL
NEDU Librarian	904-230-3100	

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INTRODUCTION

A contaminated water diving system (CWDS) includes a dry suit and an underwater breathing apparatus (UBA). Collectively, these components protect the diver from exposure to tainted water by providing complete encapsulation. In an earlier report[1], NEDU recommended adopting the Diving Systems, International (DSI; Santa Barbara, CA), contaminated water diving kit for use in the MK 21 MOD 1 UBA. This kit includes a double flapper exhaust valve and a secondary water dump valve, collectively designed to prevent water from being aspirated into the helmet along the exhaust gas train.

During initial testing at 60.6 msw (198 fsw) the interior of the helmet remained dry throughout three successive tests conducted using a 40 liter per minute (LPM) respiratory minute volume (RMV). However, when we increased the RMV to 62.5 LPM, the helmet aspirated water. We considered this level of protection sufficient for us to recommend adopting the kit in the MK 21 MOD 1 UBA for two reasons. First, a 40 LPM RMV represents a realistic breathing rate to expect from a working diver. Second, the helmet dial-a-breath knob was only adjusted at the surface; subsequent adjustments made by a diver to compensate for increased depth would reduce inhalation effort. Still, during that test series we were unable to observe the valves performing during dynamic operation, preventing us from determining the source of the aspirated water.

In the present study we used a small video camera mounted inside the UBA to provide an on-line view of the operating valves, allowing us to determine the inspiratory pressures that cause water aspiration, as well as the source of aspirated water.

METHOD

During unmanned testing[2] we used a modified[3] Navy 350 regulator. Testing was conducted using facility source air. A breathing machine provided sinusoidal breathing loops at RMVs ranging from 22.5 to 90 LPM, emulating resting to heavy diver work rates. Test depths varied from 10.1 to 60.6 msw (33 to 198 fsw). Water temperature remained at ambient, approximately 21°C (70°F).

We used a locally-fabricated "wine press" UBA holder connected to the breathing machine. The UBA was initially set up with the base of the helmet mated directly with a blanking plate, but it became evident that this test set-up produced inordinately high peak inhalation pressure (P_{inh}). The UBA neckdam provides compliance volume that attenuates P_{inh}. Lacking this compliance, a 40 LPM RMV produced P_{inh} greater than -6 kPa. Subsequently, we tested the UBA after equipping the "wine press" holder with a raised collar to securely attach a dry suit neckdam.

We continuously monitored supply overbottom pressure at the volume tank, supply pressure at the UBA side block, and peak-to-peak breathing pressures using the Macintosh®/Workbench® (Strawberry Tree, Inc., Braintree, MA) data acquisition system. Two separate video cameras, one mounted above the test ark and one inside the helmet, respectively monitored the UBA exterior and regulator valves. During the trials at deeper depths with higher RMVs we increased the volume tank overbottom pressure level to prevent P_{inh} from exceeding -4 kPa, and recorded the regulator sideblock pressure

following each adjustment.

After pressing the chamber to an assigned depth, the dial-a-breath knob was remotely adjusted at depth by servo control, thus emulating the way a diver would adjust the regulator at depth to reduce breathing resistance. Once at depth, we rotated the knob counter-clockwise until bubbles could be seen passing through the regulator whisker, then clockwise until the bubbling stopped. At that point the breathing machine was started. Testing at each depth/RMV combination was conducted for five minutes.

RESULTS

As mentioned above, during initial tests at 60.6 msw with the UBA directly mated with the blanking plate, the helmet flooded out at a 40 LPM RMV. It was clear from the video that water was directly aspirated through the regulator exhaust port, presumably due to the -6 kPa P_{inh} created by the breathing machine.

After refitting the UBA holder with a collar and setting up the UBA with a dry suit neckdam, P_{inh} was markedly lower. During these tests, the valves consistently prevented water aspiration, even when P_{inh} reached -4 kPa.

DISCUSSION

The contaminated water diving system valve kit for the MK 21 MOD 1 UBA provides ample protection against water aspiration. In the present study, video monitoring demonstrated that the valves consistently prevented water from intruding into the UBA until the breathing machine produced P_{inh} exceeding -6 kPa. At that point the valves were literally inverted, and copious amounts of water were seen spraying in through the regulator exhaust port at each inhalation stroke of the breathing machine. Even after testing stopped, the valves remained inverted.

It is important to note that during the original evaluation we used a neoprene MK 21 neckdam. Conversely, in the present study we used a dry suit neckdam. Even though we were especially careful to create a robust neckdam seal, there were times when small amounts of water were seen spraying up from below the valve ports. Thus, we conclude that the water intrusion reported earlier[1] was likely caused by a neckdam leak, and not through the contaminated water diving kit valves.

CONCLUSIONS

We continue to recommend the use of the MK 21 MOD 1 UBA equipped with the DSI contaminated water kit for Fleet contaminated water diving. Testing demonstrated that the kit provides water-tight integrity to the helmet until P_{inh} exceeds -6 kPa. This value far surpasses the P_{inh} that a diver would normally produce. In fact, two NEDU Test and Evaluation divers using maximal effort were only able to produce -5 kPa P_{inh} on the chrome-T test apparatus. Thus, the contaminated water diving kit provides sufficient protection from water aspiration across all inhalation pressures that can be reasonably expected from a diver working at depth.

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